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Physics Education: Analysis of the Effects of i>clicker Usage in the Gen Ed Classroom on Content Learning

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Introduction

The modern classroom has a wide variety of tools and technology available as aids to assist in students' content area learning. One of these tools which has gained increased popularity recently is the i>clicker, a remote device that allows students to answer questions posed by lecturers through media presentations such as PowerPoint. Lecturers are able to record and display the answers selected by the students in class, providing real-time feedback to students on material lectured on in class.

The goal of this study was to examine the effectiveness of the i>clicker device as an aid in content learning in a general education physics course. We sought to do this by analyzing the collective results of students answering content-related i>clicker questions in class correctly and comparing these results to the collective performance of students on an exam that contained a number of questions that were identical and related to those i>clicker questions asked during class, as well as a number of questions that were explicitly unassociated with i>clicker questions asked during class in the weeks preceding the exam. This represents Phase I of the research. In Phase II, we hoped to identify whether there were other identifiable factors within the structure of the exam itself that could skew the results of the analysis from Phase I.

Phase I

To begin with our analysis of i>clicker efficacy, we hypothesized the following:

1. Overall, asking i>clicker questions during class preceding the exam would assist students in learning content and increase students' performance on an exam relative to the clicker questions asked.

2. On average, those questions on the exam that were either identical or conceptually similar to those i>clicker questions asked in class would be answered correctly more often than those questions on the exam that were explicitly unassociated with i>clicker questions asked in class.

Methods I

Data was collected on the i>clicker questions asked during lectures were answered correctly. Over the course of a typical lecture, students were asked 6-8 questions, typically immediately following a sub-section of material. Students would enter in their choice of answer with their i>clicker, and after given time to answer, were shown the correct answer, as well as the distribution of answers by the students. A number of test questions that were identical, related, and completely unassociated with i>clicker questions were all designed accordingly. We also accounted for questions on the exam that were identical or similar to questions that students were quizzed on during their weekly quizzes, and considered those questions as confounded data, therefore, they were not included in the analysis.

Three content-identical versions of the exam were administered to a total of 436 students, with the only variation being the order in which the questions on the exam were asked. The first calculation was the percentage of students that answered each of the test questions of interest – Identical, Related, and Unassociated Clicker – correctly for each version of the test. Next, the average for each question of interest between the three tests was calculated. Lastly, the average percentage of correctly answered Clicker Identical, Related, and Unassociated test questions was calculated. The results, along with the data collected for how often the Clicker Identical and Clicker Related questions that were asked to students in class were answered correctly, are as follows:

Results I

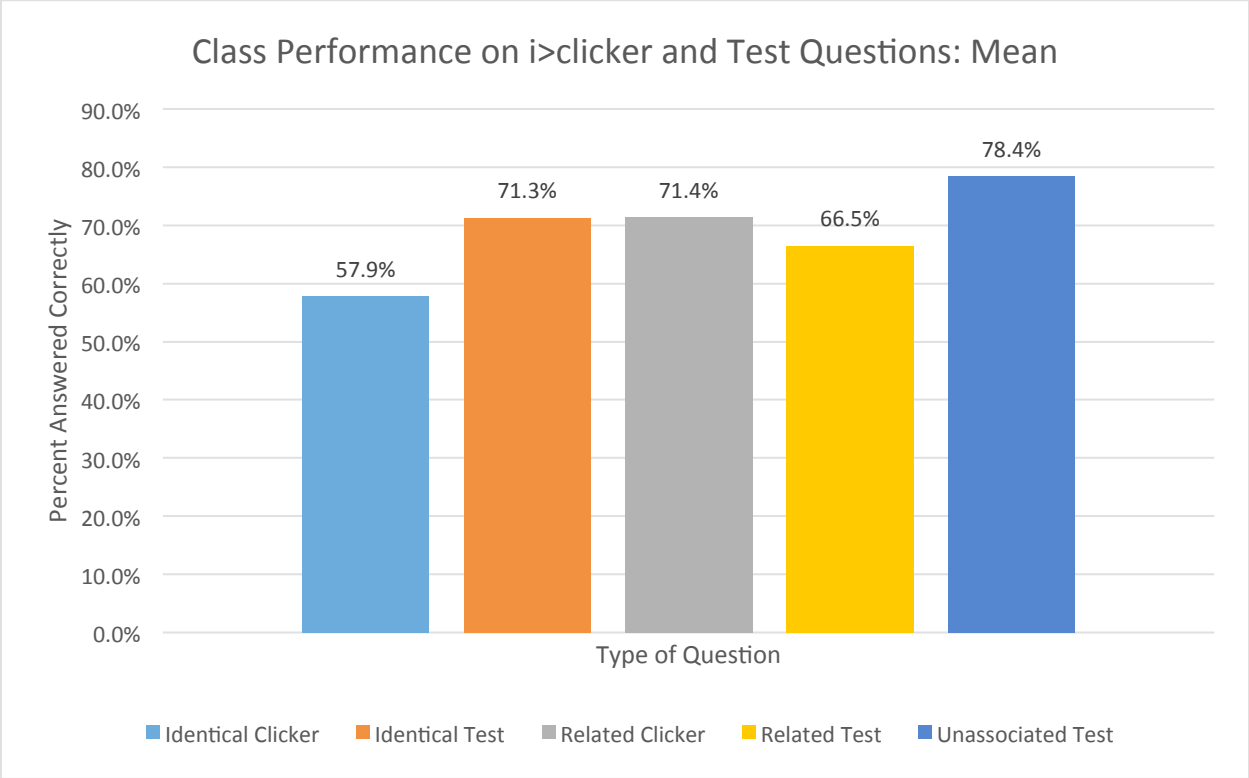

Figure 1

1. We found that, on average, 57.9% of students answered those i>clicker questions correctly that we chose to make identical test questions to, and when tested on those identical questions, 71.3% of students answered those questions correctly. This is a 13.4% increase is the amount of students that answered test questions identical to i>clicker questions correctly.

2. We also found that, on average, 71.4% of students answered those i>clicker questions that we chose to make related test questions to, and when tested on those related test questions, only 66.5% answered correctly. This is a 4.9% decrease in the amount of students that answered test questions related to i>clicker questions correctly.

3. Interestingly, the average percentage of students in the class that answered test questions that were unassociated with any i>clicker or quiz question was actually higher than the average percentage that correctly answered test questions identical or related to clicker questions, with students answering those questions correctly, on average, 78.4% of the time.

Additionally, we were interested in looking into the spread of the data and whether there was a wide variation in how often a particular type of question was answered correctly. The following figure shows the standard deviation for each type of question:

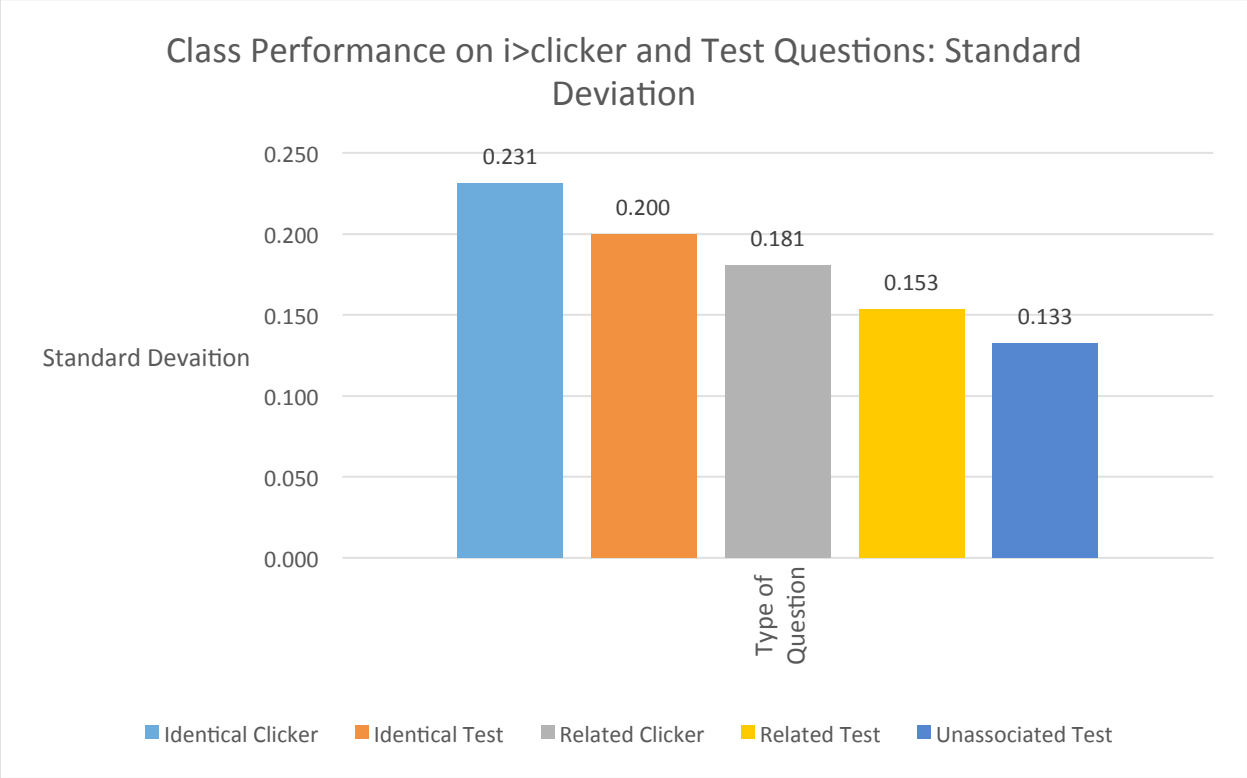

Figure 2

The data does not represent an absolute measure of the spread of the data (for example, for the Identical Test measurement, it does not mean that 67% of the time an Identical Test question would be answered correctly at 71.3 ± 20% of the time), rather, it represents a relative measure of the deviation (for example, Identical Clicker questions, with a deviation of .231, had a spread almost twice the size of Unassociated Test questions, with a deviation of .133). The analysis of the trends in the deviation is as follows:

1. The standard deviation of students that correctly answered those i>clicker questions we chose to make identical test questions to was .231, but after being asked those same questions again on the exam, the standard deviation dropped to .193.

2. The standard deviation of students that correctly answered those i>clicker questions we chose to make related test questions to was .181, and when asked those related test questions, the standard deviation dropped to .153.

3. Lastly, we found that the standard deviation of students that correctly answered test questions unassociated with i>clicker questions was only .133.

While it is premature to make any general sweeping conclusion on the effectiveness of the i>clicker as a tool for education, our results do seem to show a trend that asking students questions on a test that refer back to specific, identical questions asked in class does improve performance on exam questions of the associated concepts. However, we see the danger of assuming that a test question related to a clicker question is effective test preparation by itself, as seen by the slight decrease in how often Related Test questions were answered correctly compared to Related Clicker questions, as well as the fact that overall, Unassociated Test questions were answered correctly the most often.

Phase II

While there clearly was a noticeable difference in the variance of how often each type of question was answered correctly, as well as how often each type of question was answered correctly on average, we concluded that there were likely more factors at work than simply whether a test question was identical, related, or unassociated with an i>clicker question. We decided the next step would be to look into whether there were identifiable factors and/or trends in the test questions that would affect the difficulty of a question, thereby affecting how often that question was answered correctly. Given the breadth of the material covered on the

exam, we determined that it would be difficult to be able to quantifiably analyze and explain performance on the test based on the subject matter of a given question. We decided instead to investigate not so much *what* questions were asked, but rather *how* they were asked.

Methods II

It was along this line of investigation that we realized a significant amount of the questions asked on the exam had “All of the above” or “None of the above” as a potential answer to the question, without partiality to any particular subject within the content tested. We decided this would be a good area to investigate further, both due to the subject impartiality of the questions where these options were potential options, and also due to the fact that out of the 20 questions on the test that had “all of the above or “none of the above” as potential answers, 14 of them were questions we looked at in our initial investigation of the trends for 34 test questions that were identical, related, or unassociated to clicker questions. We calculated how often each question from our Phase I analysis that had “all of the above” or “none of the above” as potential answers was answered correctly for each individual test, as well as how often each question from Phase I that did *not* have “all of the above” or “none of the above” as potential answers was answered correctly, and averaged the results for all three tests. The results are as follows:

Results II

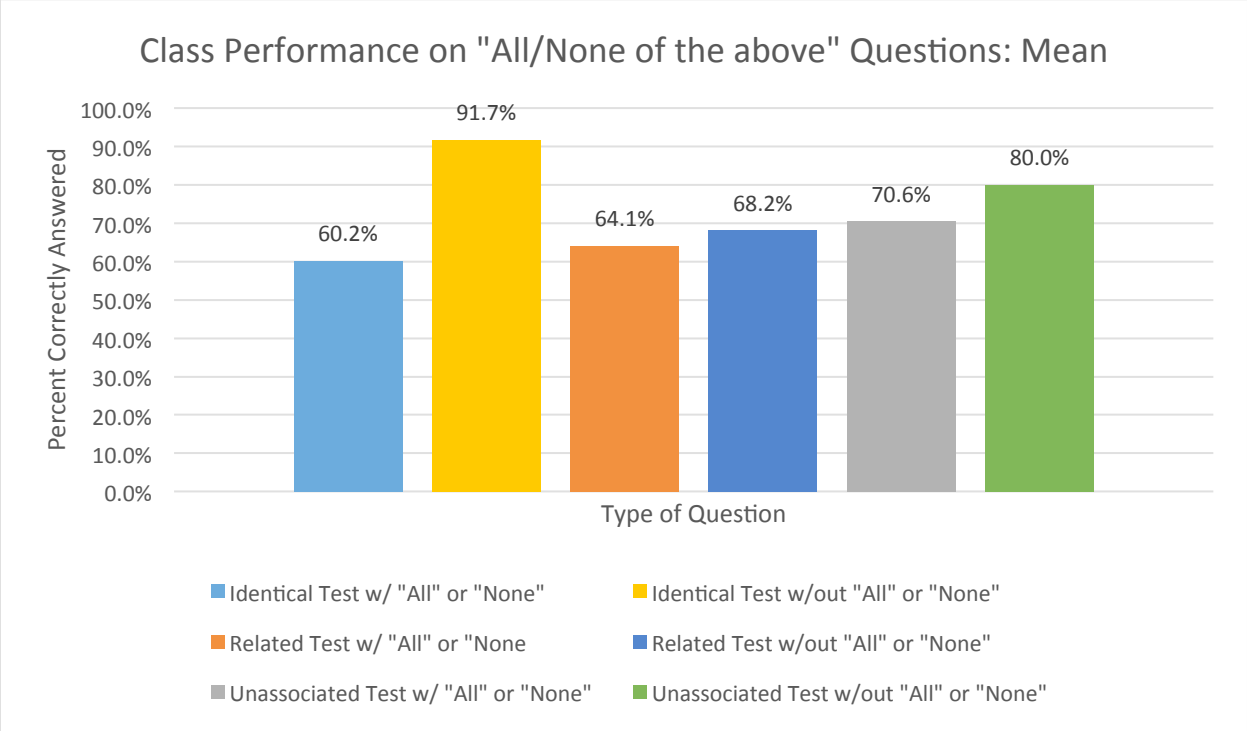

Figure 3

1. Identical Test questions that had “All of the above” or “None of the above” as potential answers were answered correctly 60.2% of the time, while Identical Test questions that did not have “All of the above” or “None of the above” as potential answers were answered correctly 91.7% of the time.
2. Related Test questions that had “All of the above” or “None of the above” as potential answers were answered correctly 64.1% of the time, while Related Test questions that did not have “All of the above” or “None of the above” as potential answers were answered correctly 68.2% of the time.
3. Unassociated Test questions that had “All of the above” or “None of the above” as potential answers were answered correctly 70.6% of the time, while Unassociated Test

questions that did not have “All of the above” or “None of the above” as potential answers were answered correctly 80.0% of the time.

Much to our surprise, in *all* cases, those categories of questions that had “All of the above” or “None of the above” as potential answers were answered correctly *below* the average of how often those same types of questions were answered correctly in general (refer back to Figure 1 for the mean percentage of each type of question being answered correctly). We suspect that the greater disparity between Identical Test questions with and without “All of the above” or “None of the above” as potential answers, as well as the disparity between Unassociated Test questions with and without “All of the above” or “None of the above” as potential answers is due to uneven sample sizes of questions. Out of the seven total Identical Test questions, six of them had “All of the above” or “None of the above as potential answers, while only two did not. Likewise, out of the twelve Unassociated Test questions on the exam, only two had “All of the above” or “None of the above as potential answers, whereas ten did not. These are both in contrast to the Related Test questions, of which six had “All of the above” or “None of the above” as potential answers, while eight did not.

Conclusion

Although the sample size of each type of question are not even, the results are definitely intriguing. Regardless of the type of question asked, on average, questions that had all or none of the above as an option were answered correctly below the total average answered correctly for each respective type of question. It is likely that the performance of students on the test was influenced not only by the exposure and lack of exposure to test questions identical, related, and unassociated with clicker questions asked in class, but also by whether or not the

question asked had “all of the above” or “none of the above” as potential answers to each respective question.

Due to this combination of factors it is vital in future research to create a significant sample of clicker identical, related, and unassociated test questions on an exam, with equal amounts of questions containing “all of the above” or “none of the above” as potential answers as questions that do not contain those options as potential answers. Such an analysis would provide a more detailed and accurate assessment of the effectiveness of i>clickers as useful education tools. Further research is also necessary to determine why students overall performed significantly better on those test questions which were completely unassociated with any clicker question. We would be interested to investigate if there is any bias towards choosing “All of the above” or “None of the above” when they are potential answers to questions. An idea of how to approach this is to see how often each of the potential answers for those questions where “All of the above” or “None of the above” are potential answers are chosen by students on the exam as the correct answer in order to investigate if those potential answers to the questions are chosen more often than the remaining options when they are not the correct answer.